THE SPECIFICATION, ANALYSIS, AND EXECUTION OF REQUIREMENTS AND DESIGNS FOR REAL-TIME SYSTEMS

FINAL PROGRESS REPORT

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13. ABSTRACT (Maximum 200 words)

The goal was to further develop a methodology, language, and tools, based on state-machines, for describing, analyzing, and executing requirements and designs for concurrent and distributed real-time systems.

Using our communicating real-time state machine (CRSM) notation , we showed how specifications-in-the-large could be obtained with simple mechanisms for composing CRSMs into subsystems and larger systems, and how assertion checking can be employed to monitor systems changes . Events and data messages that are communicated among distributed components are often time-stamped as a way to handle timing constraints, ordering, and causality; the idea of time-stamped event histories, i.e., sequences of time-stamped events ordered by time, was developed as a new real-time programming object and supported by an implementation extension of our CRSM simulator. Our current work is focused on real-time communication models that fit naturally into a state-machine framework and that can be applied to the many and diverse forms of distributed communication that exist.

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A. STATEMENT OF THE PROBLEM STUDIED

The general problem and purpose was to develop methods for specifying and analyzing real-time systems. In particular, the goal was to further develop a methodology, language, and tools, based on state-machines, for describing, analyzing, and executing requirements and designs for concurrent and distributed real-time systems. Emphasis was on the handling of time, scalability, and real-time communications.

B. SUMMARY OF THE MOST IMPORTANT RESULTS

Using our communicating real-time state machine (CRSM) notation[1], we showed how specifications-in-the-large could be obtained with simple mechanisms for composing CRSMs into subsystems and larger systems, and how assertion checking can be employed to monitor systems changes[2]. Events and data messages that are communicated among distributed components are often time-stamped as a way to handle timing constraints, ordering, and causality; the idea of time-stamped event histories, i.e., sequences of time-stamped events ordered by time, was developed as a new real-time programming object and supported by an implementation extension of our CRSM simulator[3] [4]. Finally, our current work is focused on real-time communication models that fit naturally into a state-machine framework and that can be applied to the many and diverse forms of distributed communication that exist.

In addition to the publications listed in Part C, the research was also disseminated via several invited talks. The PI gave an invited presentation at the First International Workshop on Real-Time Computer Systems and Applications in Seoul, Korea, in December, 1994 on the topic "Specifying large real-time systems with communicating real-time state machines." He also gave one of the keynotes at the Twenty-third IFAC/IFIP Workshop on Real-Time Programming, Shantou, China, in June, 1998. Finally, at the July 1998 ARO Workshop on Software Design Automation for Reactive Systems, Shaw delivered an invited talk on "Some software challenges in large monitoring and control systems."

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[1] A. Shaw, "On scalable state-based specifications for real-time systems," Technical Report # 94-02-03, Department of Computer Science and Engineering, University of Washington, 1994.

S. Raju and A. Shaw, "A prototyping environment for specifying, executing, and checking communicating real-time state machines," *Software Practice and Experience*, v.24, no.2, 1994, pp.175-195.

[2] A. Shaw, "Temporal state machines and assertions: a practical framework for handling changes in real-time systems," *Proceedings of the 1994 ONR/ARPA/AFOSR/ARO/NSF Monterey Workshop on Software Evolution*, Monterey, CA, September 1994, pp145-149.

[3] A. Shaw, "Time-stamped event histories: a real-time programming object," *Control Engineering Practice*, 6, 3 (March 1988), pp.417-420. (An earlier version appeared in M. Maranzana (ed.), *Proceedings of the 22nd Annual Workshop on Real-Time Programming*, Pergamon Press, September 1997, pp77-80)

[4] A. Shaw, "Real-time programming with time-stamped event histories," *Proceedings of the ARO Workshop on Systems and Control and Software Knowledge-Based Systems*, Research Triangle Park, NC, February 1996, pp.72-74. (A longer updated version with the same title and by A. Shaw and D. Rupp is Technical Report UW-CSE-96-05-02, Department of Computer Science and Engineering, University of Washington, May 1996.)

C. LIST OF ALL PUBLICATIONS AND TECHNICAL REPORTS

1. L. Alfaro, "Evaluation of scheduling algorithms for air traffic control," M.S. thesis, Department of Industrial Engineering, University of Washington, August 1998.

2. S. Sandys and A. Shaw, "Requirements specifications for real-time communications," Technical Report UW-CSE-98-12-03, Department of Computer Science and Engineering, University of Washington, December, 1998.

3. A. Shaw, "Time-stamped event histories: a real-time programming object," *Control Engineering Practice*, 6, 3 (March 1988), pp.417-420. (An earlier version appeared in M. Maranzana (ed.), *Proceedings of the 22nd Annual Workshop on Real-Time Programming*, Pergamon Press, September 1997, pp77-80)

4. A. Shaw, "A case for object-oriented real-time systems," *Real-Time Systems Journal*, in publication, 1999.

5. A. Shaw, "Real-time programming with time-stamped event histories," *Proceedings of the ARO Workshop on Systems and Control and Software Knowledge-Based Systems*, Research Triangle Park, NC, February 1996, pp.72-74. (A longer updated version with the same title and by A. Shaw and D. Rupp is Technical Report UW-CSE-96-05-02, Department of Computer Science and Engineering, University of Washington, May 1996.)

6. A. Shaw, "Temporal state machines and assertions: a practical framework for handling changes in real-time systems," *Proceedings of the 1994 ONR/ARPA/AFOSR/ARO/NSF Monterey Workshop on Software Evolution*, Monterey, CA, September 1994, pp145-149.

D. LIST OF ALL PARTICIPATING SCIENTIFIC PERSONNEL SHOWING ANY ADVANCED DEGREES EARNED BY THEM WHILE EMPLOYED ON THE PROJECT

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- Sean Sandys, Graduate Student Research Assistant (current Ph.D. student)
- Alan Shaw, Professor (Principal Investigator)